REMARKS

This Application provides for a method of and apparatus for measuring twist due to torque in a shaft of an engine. The shaft transmits torque generated by the engine to a rotary load. Time lags in arrival of points on the shaft at fixed measuring stations are measured to indicate twist in the shaft caused by the torque. The effects of vibrations and resonances in rotating or reciprocating components of the engine are ameliorated by means of a pre-programmed processor to isolate, at least to a degree, useful data from noise, the useful data being used to calculate the torque.

Applicants confirm that the subject matter of the claims on file and as amended was commonly made by the inventors.

The specification is amended to follow the lay-out in accordance with the guidelines;

The following claims are now pending:

Claims 37 to 39;
Claim 44;
Claim 50;
Claims 52 to 54;
Claim 57 and
Claim 66 to 73.

Claims 37, 50 and 52

Claims 37 and 50 are independent method claims, and claim 52 is an independent apparatus claim corresponding generally to claim 37. The amendments introduced to these claims are substantially the same for all three claims. Thus, for economy of writing, the following remarks are directed specifically at claim 37, but apply equally and are repeated also in respect of claims 50 and 52.

Claim 37 is now limited to ameliorating the effects of vibrations and resonances to isolate useful data from noise in the signal, by means of a pre-programmed computer. This amendment is fairly based on the specification, page 10, lines 24 to 29.

The patent to Leon (Leon) recognizes the problem of noise pollution of useful data and proposes eliminating vibrations in the sensors by mounting all of the sensors on a unitary, rigid frame surrounding the shaft being investigated. Leon is directed at investigating straight shafts intermediate series connected turbines in a train of turbines, in which the shafts are readily accessible or exposed and such surrounding frames can be accommodated around the shafts. The invention disclosed in Leon has various drawbacks. The frame can at best be relatively rigid and not absolutely rigid, and following on that the frame, in practice, has to be compact, both in length and in diameter. In practice, the invention of Leon can be applied only to short length portions of straight shafts without external components or formations surrounding such length of the shaft to be investigated. The sensors have to be provided in diametrically opposed pairs, and the pairs are longitudinally spaced, i.e. a minimum of four sensors are required. The most important disadvantage is that the frame has to be accommodated around the shaft and the required space thus has to be available. This is particularly onerous, and in practice is rendered effectively incapable of use in the case of investigating a shaft internally of an engine, as opposed to an external, exposed shaft.

In contradistinction, the current invention, in claim 37 proposes pre-programming the processor (with appropriate software) to insulate the useful signal content from noise. It is well recognized that, generally, the use of a computer and software is much preferred over a mechanical solution in respect of costs, reliability, versatility, compactness, user-friendliness, and the like. Thus, the feature of claim 37 is an important step forward. A large advantage is that this method step does not lead to encroachment on volumes proximate the shaft and is thus non-invasive.

It is contended that claims 37, 50 and 52 are now distinguishable over the prior art, whether taken singly or in combination, and these claims should now be allowed.

Claims 38 and 53

Leon discloses investigating a shaft connecting an engine generating torque with a load consuming torque. Leon is necessarily applied to an external, exposed portion of the shaft. It discloses neither a measure point nor a datum point on a relaxed portion of the shaft.

With reference to Leon, column 7, lines 37 to 52 referred to by the Examiner, Leon merely discloses taking readings at zero torque loads initially to establish a zero torque relationship between the respective reading stations (see lines 39-40). It is fundamental to Leon that the torque on the shaft at both reading stations and over the whole of the length portion being considered is constant. It is thus not correct to say that Leon discloses the feature of claims 38 and 53.

The practical value and advantage of the feature of claims 38 and 53 is that the measure / datum point in the relaxed portion can be at any convenient longitudinal position, as no twist takes place between that point and the position at which the torque is applied. This allows much freedom in selecting an appropriate longitudinal position for the respective measure / datum point.

Claims 39 and 54

Currently amended claim 39 combines the features of previously presented claims 39 40, 41 and 48. Similarly, currently amended claim 54 combines the features of previously presented claims 54 to 56.

The patent to Moine et al (Moine), which was combined with Leon to reject claims 40-42 and 55-56, is directed to a very different technological solution for determining mean gas torque and measures merely time periods between arrival times of a plurality of circumferentially spaced points at the same longitudinal position. It uses regression and progression in such time periods to obtain a result related to the magnitude of mean gas torque during a power stroke of an internal combustion engine. It does not measure strain or twist caused by torque in an elongate member.

Applicants contend that the only resemblances of the current invention to the disclosure in Moine are application to a reciprocating internal combustion engine, sensing of the time periods at which ring gear teeth pass a fixed station, and that a result of the measurements and calculations relates to a power stroke. The current invention is so far removed from Moine that one wishing to apply the method of Leon on an engine shaft, would not seek assistance from Moine. Applicants thus contend that it would not be obvious to combine Moine with Leon to obtain a selected combination.

Claims 39 and 54 clearly disclose a ring gear with teeth providing the plurality of measure points at one end of the crank shaft, and a disc having a plurality of datum points circumferentially spaced on the disc at an opposed end of the crank shaft. Neither Leon nor Moine discloses such a disc; neither Leon nor Moine discloses a plurality of datum points on such a disc. Inherent in the method and construction defined by claims 39 and 54, also bearing in mind the dependency of claim 39 on claim 38, is that the disc, at an end of the crank shaft opposed to the ring gear, and thus the datum points, are on a relaxed portion of the crank shaft.

It is contended that claims 39 and 54 are not disclosed in the prior art citations, neither singly, nor in combination, and the allowance of claims 39 and 54 is solicited.

Claims 44 and 57

Currently amended claim 44 combines the features of previously presented claims 44 and 46. Currently amended claim 57 combines the features of previously presented claims 57 and 59-61.

Claims 44 and 57 are directed to applying the current invention to a gas turbine engine, more specifically the main shaft thereof. Measuring torque takes place between a plurality of vanes providing measure points, and a plurality of vanes providing datum points, at longitudinally spaced positions respectively on a compressor and a turbine of the gas turbine engine.

Leon discloses a train of turbines, such as at a power station, interconnected by shafts extending intermediate the turbines, to be drivingly connected in series, e.g. to drive a common alternator or generator. It further discloses measuring on each of the connecting shafts, over a length of shaft having constant torque, the values of such torque and by simply subtracting the respective torque values from one another, calculating the torque contribution of each turbine.

Leon does not disclose application to a gas turbine engine, and *a fortiori,* it does not disclose application to a main shaft carrying a compressor and turbine of a gas turbine engine.

Leon discloses measuring discreet torque values at discreet positions of the respective connecting shafts, investigating a short length of shaft which has constant torque and which is exposed. Leon does not disclose using vanes as measure / datum points and Leon can in any case not be used in that way as it would be physically impossible in a practical application to apply Leon's unitary, rigid frame around the casing of a gas turbine engine.

The features of claims 44 and 57 are thus not at all disclosed in Leon and allowance of claims 44 and 57 is thus solicited.

Claims 66 and 67, and claims 69 and 70

Claim 66 is currently amended to correct a grammatical error.

In Leon, column 8 lines 21 to 39 referred to by the Examiner, merely a portion of the calculation of the shaft wind up angle is disclosed. A zero-torque reading is subtracted from a non-zero- torque reading to calculate a value attributable to torque, more specifically the angle to which the shaft is wound up on account of the torque. Leon does not disclose in the portion referred to by the Examiner, the use of measurement results in comparison to a standard or norm to control an operating function of the engine. Nor is it apparent that Leon discloses this at all. At most Leon alludes to merely diagnosing that one turbine in the train of turbines is under performing, and identifying the culprit turbine. It does not teach controlling an operating function of the culprit turbine. *A fortiori*, it does not control any one of the operating functions as identified in respectively claims 67 and 70.

Neither does Moine disclose controlling an operating function in response to deviation between a measured value and a standard or norm. *A fortiori*, Moine does not disclose controlling an operating function as identified in respectively claim 67 and 70.

Claims 68 and 71

The Examiner has not cited prior art that discloses automatic calibration of the measuring apparatus in respect of datum time periods when the engine is operating under a no load condition. At most, taking measurements under no load conditions is disclosed, but not calibrating.

Claims 72 and 73

These new claims are directed at an especially convenient and advantageous way of pre-programming the computer to insulate the required data from noise, namely by means of Fast Fourier Transforms. As not even the general feature of claims 37, 50 and 52 is disclosed in the prior art, *a fortiori*, the feature of claims 72 and 73 is not disclosed in any of the prior art citations.

It is believed that the claims now present in this application are all distinguishable over the prior art citations, whether taken singly or in combination, and the Examiner is earnestly requested to allow these claims.

Respectfully submitted,

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